

# **King County Marine Ambient Monitoring Program**

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## **2009 Subtidal Sediment Sampling Event**

### **Sampling and Analysis Plan**

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Prepared for the

King County Department of Natural Resources and Parks  
Water and Land Resources Division

by the

King County Department of Natural Resources and Parks  
Marine and Sediment Assessment Group

June 2009

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Prepared by

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# **1 INTRODUCTION**

This sampling and analysis plan (SAP) presents project information and sampling and analytical methodologies that will be employed to perform subtidal sediment sampling in 2009 for King County's marine ambient monitoring program. This work is being performed as part of a long-term sediment monitoring program designed to assess sediment quality in Elliott Bay, the Central Basin of Puget Sound proximal to King County, and three smaller embayments. The SAP includes a description of the project, sampling and analytical methodologies, and reporting requirements. All figures referenced in the SAP may be found at the end of the narrative. This SAP has been prepared in accordance with Washington State Department of Ecology (Ecology) sampling and analysis plan preparation guidance (Ecology 2008) as well as Chapter 173-204 WAC, the Washington State Sediment Management Standards (Ecology 1995).

## **2 PROGRAM DIRECTIVES**

King County's marine ambient monitoring program gathers water, sediment, and biota data in the Central Basin of Puget Sound, including Elliott Bay and the Duwamish River. These data are used to provide an understanding of water and sediment quality issues – both to assess the general health of the Puget Sound marine environment within King County and as a comparative aid to confirm that discharges from the County's wastewater outfalls are not adversely affecting the marine environment. The marine ambient monitoring program is also part of an intergovernmental effort, the Puget Sound Assessment and Monitoring Program (PSAMP), that monitors the health of the Puget Sound marine environment on a larger-scale, region-wide basis.

## **3 MONITORING HISTORY**

King County has collected sediment quality data from subtidal ambient monitoring stations for many years; formerly on an annual basis and biennially between 1996 and 2004. These subtidal monitoring stations were located within Elliott Bay and in the Central Basin, proximal to the City of Seattle. Sampling locations were traditionally located to monitor sediment quality in areas within the general vicinity but away from the direct impact of potential point-source pollution such as wastewater and storm water outfalls and general non-point sources such as the Duwamish River.

Samples were collected from the top two centimeters (cm) of sediment and analyzed for metals and organic chemicals in order to evaluate sediment quality in the most-recently deposited material. Sediment quality has been evaluated by comparing metals and organics concentrations to the published sediment quality chemical criteria of the Washington State Sediment Management Standards (SMS) as well as Puget Sound region-wide sediment data.

The former subtidal sediment monitoring program was temporarily discontinued after 2004 to provide an opportunity for King County staff scientists and a peer review panel to evaluate data generated from the program as well as other data collection efforts within the region. Following this review, King County expanded its marine ambient subtidal sediment monitoring program in 2007 to focus on sediment quality in Elliott Bay, while still

monitoring truly ambient sediment quality in the Central Basin, including three smaller embayments of interest. The Elliott Bay sediment monitoring program includes eight stations with sampling occurring every two years. The other six stations will be sampled every five years. The 14 stations that were sampled initially in 2007 are shown in Table 3-1.

**Table 3-1**  
**Marine Ambient Subtidal Sediment Monitoring Stations**

<b>Station</b>	<b>Description</b>	<b>Schedule</b>	<b>Rationale</b>
KSBP01	Central Basin – Point Jefferson	Every 5 Years	North Central Basin water quality station.
LSML01	Central Basin – West Seattle	Every 5 Years	Long-term sediment monitoring station.
NSEX01	Central Basin – East Passage	Every 5 Years	South Central Basin water quality station.
KSRU03	Outer Salmon Bay	Every 5 Years	Potential impact from locks/vessel traffic.
LSVV01	Fauntleroy Cove	Every 5 Years	History of water quality issues/ferry traffic.
MSVK01	Inner Quartermaster Harbor	Every 5 Years	Important habitat area/high recreational use.
KSZY01	Elliott Bay - Piers 90/91	Every 2 Years	Location of large vessel traffic/docking.
LTAA02	Elliott Bay - Grain Terminal	Every 2 Years	Location of large vessel traffic/docking.
LSCW02	Elliott Bay - Outer	Every 2 Years	Long-term sediment monitoring station.
LTCA02	Elliott Bay - North Central	Every 2 Years	Long-term sediment monitoring station.
LTDF01	Elliott Bay - Waterfront	Every 2 Years	Long-term sediment monitoring station.
LTED04	Elliott Bay - South Central	Every 2 Years	Long-term sediment monitoring station.
LSHZ08	Elliott Bay - Cove 2	Every 2 Years	High recreational use/sediment contact.
LTGF01	Elliott Bay - Harbor Island	Every 2 Years	Location of heavy industry/shipbuilding.

The 2009 marine ambient subtidal sediment sampling event will focus on the eight stations located in Elliott Bay.

## 4 SAMPLING DESIGN

The primary goal of the marine ambient sediment monitoring program is to collect data of known quality in order to effectively characterize marine sediments within King County. The eight stations located in Elliott Bay began a biennial sampling regime in 2007. This sampling frequency will allow King County and other decision-makers to better evaluate temporal changes in sediment quality and help assess the potential positive impacts to the marine environment from various sediment cleanup projects and other riparian improvements in Elliott Bay. Four of the Elliott Bay stations have long-term sediment quality data sets that will continue with King County's new sediment sampling program. These stations are:

- LSCW02 – located at the hypothetical boundary-line between Elliott Bay and the Central Basin of Puget Sound;
- LTCA02 – located in the center of Elliott Bay;
- LTED04 – located in the center of Elliott Bay, inshore of LTCA02; and
- LTDF01 – located along the central Seattle waterfront, near Pier 66.

These four stations form a rough east-west transect away from locations of potential point-source impacts to the sediment. The four other Elliott Bay stations added to the monitoring program in 2007 will assess specific areas of the bay. These stations are:

- KSZY01 – located just offshore of Piers 90/91. This area has historically received high heavy-vessel traffic and will continue to receive large ships when cruise liners begin using these docking facilities.
- LTAA02 – located just offshore of the grain terminal. This area has also historically received high heavy-vessel traffic and docking.
- LTGF01 – located just offshore of the northern end of Harbor Island. This location is in an area of heavy industry, including fuel storage and transfer, shipbuilding and repair, and the transportation industry.
- LSHZ08 – located just offshore of Cove 2 at Seacrest Park. This area has high usage by recreational SCUBA divers, including diving classes, which provides a high incidence of primary contact with bottom sediments, especially by student divers.

#### **4.1 Data Quality Objectives**

The data quality objectives (DQOs) of the 2009 subtidal sediment sampling event are to collect data of sufficient *quantity* and *quality* to be able to meet the following study goals:

- evaluate the areal extent and spatial variations of sediment chemical concentrations in Elliott Bay;
- compare sediment chemical concentrations to Puget Sound-wide regional values; and
- evaluate sediment chemical concentrations relative to the current marine sediment quality standards of Chapter 173-204 WAC (Ecology 1995).

The *quantity* of sediment chemistry data to be collected is based on previous sampling events conducted under King County's marine ambient monitoring program as well as Ecology's marine sediment monitoring program, conducted in association with PSAMP. Four of the sampling stations in this monitoring event were sampled biennially between 1996 and 2004 and last sampled in 2007. The other four stations were first sampled in 2007. One sediment sample will be collected from each of eight stations. The spatial distribution of King County's eight sediment monitoring stations in Elliott Bay complements Ecology's stations for their Urban Waters Initiative monitoring program, which also began sampling Elliott Bay in 2007. The biennial frequency of King County's sediment monitoring program in Elliott Bay will supplement the data collected under the Urban Waters Initiative, which monitors Elliott Bay once every five years.

Validation of project data will assess whether the data collected are of sufficient *quality* to meet the study goals. The data quality issues of precision, accuracy, bias, representativeness, completeness, comparability, and sensitivity are described in the following sections.

##### **4.1.1 Precision, Accuracy, and Bias**

Precision is the agreement of a set of results among themselves and is a measure of the ability to reproduce a result. Accuracy is an estimate of the difference between the true value and the determined mean value. The accuracy of a result is affected by both systematic and random errors. Bias is a measure of the difference, due to a systematic factor, between an analytical result and the true value of an analyte. Precision, accuracy, and bias for sediment chemistry will be measured by the following quality control (QC) analyses: method blanks, spike blanks, matrix spikes, matrix spike duplicates, certified reference materials, laboratory control samples, and laboratory duplicates or triplicates.

#### **4.1.2 Representativeness**

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at the sampling point, or an environmental condition. Sediment chemistry samples will be collected from stations with pre-selected coordinates to represent specific site locations. Sediment chemistry samples will be homogenized to minimize variations in the chemical and physical composition of the sediments. Following the guidelines described for sampler decontamination, sample acceptability criteria, and sample processing (Section 6) will also help ensure that samples are representative.

#### **4.1.3 Completeness**

Completeness is defined as the total number of samples for which acceptable analytical data are generated, compared to the total number of samples submitted for analysis. Adhering to standardized sampling and testing protocols will aid in providing a complete set of data for this study. The goal for completeness is 100%. If 100% completeness is not achieved, the study team will evaluate whether the DQOs can still be achieved or if additional samples may need to be collected and analyzed.

#### **4.1.4 Comparability**

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. This goal is achieved through using standard techniques to collect and analyze representative samples, along with standardized data validation and reporting procedures. By following the guidance of this SAP, the goal of comparability will be achieved.

#### **4.1.5 Sensitivity**

Sensitivity is a measure of the capability of analytical methods to meet study goals. The sediment chemistry analytical method detection limits presented in Section 9 are sensitive enough to allow comparison of sediment chemistry data to current Ecology sediment quality criteria, both normalized to dry weight and to organic carbon, as appropriate.

### **4.2 Sampling Strategy**

Sediment chemistry samples will be collected from eight stations located in Elliott Bay. Samples will be collected from the top 2 cm of sediment to evaluate chemical concentrations in the most-recently deposited material. All field work will be conducted on board King County's research vessel *Liberty*.

#### **4.2.1 Location of Sampling Stations**

Sediment chemistry samples will be collected from the eight stations shown in Figure 1. Coordinates and water depth for these stations are shown in Table 4-1.



**Table 4-1****2009 Marine Ambient Subtidal Sediment Monitoring Stations – Coordinates and Water Depths**

Station	Description	Northing (NAD83)	Easting (NAD83)	Approx. Depth (ft.)
KSZY01	Elliott Bay - Piers 90/91	231983	1258639	60
LTAA02	Elliott Bay - Grain Terminal	231054	1261260	80
LSCW02	Elliott Bay - Outer	227106	1256271	590
LTCA02	Elliott Bay - North Central	226303	1260915	430
LTDF01	Elliott Bay - Waterfront	225367	1267270	110
LTED04	Elliott Bay - South Central	223909	1264675	300
LSHZ08	Elliott Bay - Cove 2	218767	1259170	80
LTGF01	Elliott Bay - Harbor Island	218854	1265592	100

**4.2.2 Sample Acquisition and Analytical Parameters**

Sediment chemistry samples will be collected from the 0- to 2-cm depth stratum to characterize the most recently deposited material. Samples will be composited from sediment recovered from a single deployment of dual, tandem 0.1 m<sup>2</sup> modified van Veen grab samplers. Samples will be composited, homogenized, and split into laboratory containers in the field. Parameters of interest will include trace metals and organic compounds, as well as conventional sediment chemistry and physical properties.

Sediment chemistry analytical parameters were selected primarily based on guidance for conducting sediment characterizations (Ecology 2008) as well as for consistency with Ecology's ambient sediment monitoring program and will allow comparison of analytical results with published sediment quality criteria (Ecology 1995). Other analytical parameters were selected based on previous sediment studies in the vicinity, as well as a desire to begin monitoring emerging chemicals of concern such as nonylphenols and polybrominated biphenyl ethers (PBDEs). Analytical parameters will include:

- conventionals – ammonia, particle size distribution (PSD), total organic carbon (TOC), total solids, and total sulfide;
- metals – aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, silver, tin, and zinc; and
- organics - base/neutral/acid semivolatile organic compounds (BNAs), butyltins, chlorinated pesticides, PBDEs, polychlorinated biphenyls (PCBs), and total nonylphenols (the complete list of organic parameters is shown in Section 9.3).

**4.3 Data Analysis**

Chemistry data will be evaluated by comparison to sediment chemical criteria from Tables I and III in the Washington State Sediment Management Standards (SMS) of Chapter 173-204 WAC (Ecology 1995). Data from this sampling event will be compared to results from previous King County monitoring events as well as other sediment studies in Puget Sound.

Sediment data for some organic compounds are generally normalized to organic carbon content for comparison to SMS criteria. Normalization to organic carbon can produce biased results, however, when the organic carbon content of the sample is very low (Ecology 1992). When the organic carbon content of a sample is near 0.1 or 0.2% (1,000 to 2,000 milligrams/kilogram (mg/Kg) dry weight, even background concentrations of certain organic compounds can exceed sediment quality criteria. If the organic carbon content at any

particular station is below 0.5% dry weight, then dry weight-normalized results for non-ionizable organic compounds will be compared to Lowest Apparent Effects Threshold (LAET) or Second Lowest Apparent Effects Threshold (2LAET) criteria (EPA 1988), rather than SMS criteria.

## 5 PROJECT ORGANIZATION AND SCHEDULE

The tasks involved in conducting the 2009 marine ambient subtidal sediment sampling event and the King County personnel who will assume responsibility for those tasks are listed below.

- **Scott Mickelson** King County Marine and Sediment Assessment Group – 206.296.8247 [scott.mickelson@kingcounty.gov](mailto:scott.mickelson@kingcounty.gov) Project management, study design, preparation of SAP, data validation and analysis, and preparation of final study report.
- **John Blaine** King County Environmental Laboratory – 206.684.2384 [john.blaine@kingcounty.gov](mailto:john.blaine@kingcounty.gov) Coordination of all field sampling activities.
- **Katherine Bourbonais** King County Environmental Laboratory – 206.684.2382 [katherine.bourbonais@kingcounty.gov](mailto:katherine.bourbonais@kingcounty.gov) Coordination of all laboratory analytical activities, data validation, and data reporting.
- **Colin Elliott** King County Environmental Laboratory – 206.684.2343 [colin.elliott@kingcounty.gov](mailto:colin.elliott@kingcounty.gov) Review of SAP, coordination of laboratory quality control, data validation, and data reporting.

Sampling for the 2009 marine ambient subtidal sediment sampling event is anticipated to require up to three days of field time (weather dependent) and will be completed in June 2009. Analytical results for sediment chemistry will be available by October 2009. Validated chemistry data packages and electronic data files will be ready for release by November 1, 2009.

## 6 SAMPLING PROCEDURES

All sampling will be performed according to guidelines recommended by the Puget Sound Estuary Program's (PSEP) Puget Sound Protocols (PSEP 1997a and 1998). Sampling will be performed by staff of the King County Environmental Laboratory. Sediment samples will be collected using dual, tandem 0.1 m<sup>2</sup> modified, stainless steel van Veen grab samplers deployed via hydrowire and hydraulic winch from King County's research vessel *Liberty*.

Samples will consist of the top 2 cm of sediment collected, ideally, from the contents of a single deployment of the dual grab samplers. Additional grab deployments may be necessary, dependent upon the substrate, to collect enough sediment to perform all analyses. Sediment samples will be stored on ice in coolers while in the field, then transported to the King County Environmental Laboratory at the end of each sampling day. Established chain of custody (COC) procedures will be followed for this sampling event.

### 6.1 Station Positioning

Reliable station positioning is crucial to be able to revisit established stations for future sampling events. Inaccuracies in station positioning when conducting sediment grab

sampling in deep water can result from the action of currents and wind on the sampling vessel as well as current forces and viscous drag on the sampler and deployment line.

Station positioning for the 2009 sampling event will employ a combination of a differential global positioning system (DGPS), acoustic transponder beacon, motion sensor, and positioning software to calculate the exact position of the van Veen grab sampler as it contacts the seafloor. Use of this enhanced positioning system during previous sampling efforts conducted by King County has indicated a precision of  $\pm 10$  feet around a prescribed sampling location.

For station positioning, the research vessel will employ a Trimble® DGPS. Prior to the sampling event, the prescribed station coordinates will be entered into the shipboard DGPS laptop computer. During the sampling event, the shipboard navigational system will utilize the differential data transmissions from regional Coast Guard base stations to automatically correct its GPS satellite data. The GPS antenna is boom-mounted above the sampler descent line to achieve a more accurate coordinate fix above the sampling point.

To increase sampling accuracy for those stations with depths greater than 50 meters, the DGPS system will be enhanced by the addition and integration of an ultra-short baseline (USBL) acoustical navigation system that will continuously calculate the three-dimensional position of the submerged grab samplers, relative to that of the surface vessel. An electronic compass will be used to reference all underwater directional data to magnetic north. Previous usage has shown that underwater positioning accuracy is not substantially increased when sampling at those stations shallower than 50 meters. In addition, the close proximity of these stations to shorelines creates acoustic interferences that effectively nullify the effectiveness of the USBL equipment.

Upon contact of the grab sampler with the bottom, the coordinate data representing the actual sediment grab impact point will be electronically recorded in real time. Positioning information will include local time and date that a position is recorded, comments, and coordinate data in both latitude/longitude and NAD 83 State Plane formats.

Sample collection is expected to take place within a 6-meter radius of each station's prescribed position and samples will not be collected if the observed coordinates of the grab deployment are outside of this limit. If conditions such as a steep slope or rocky substrate preclude sample collection at a particular station, the station may be relocated after consultation with the study coordinator and if relocation will not compromise the project goals. Any station relocation will be documented and reported.

## **6.2 Sampler Deployment and Retrieval**

Two 0.1 m<sup>2</sup> modified, stainless-steel van Veen grab samplers will be deployed in tandem at each sampling station. The grab samplers will be lowered at a controlled speed of approximately three feet per second until they near the bottom, at which time the speed will be decreased to approximately one foot per second to minimize potential bow wake activity and subsequent bottom disturbance.

After the grabs have tripped upon reaching the bottom, they will be raised slowly to allow gentle and complete closure of the sampler jaws to avoid sample disturbance and loss. Once clear of the bottom, the ascent speed will be increased to approximately three feet per second.

Care will be taken to ensure that minimal sample disturbance occurs when swinging the grabs on board. Collection of undisturbed sediment requires that the grab samplers:

- create a minimal bow wake when descending;
- form a leak-proof seal upon closure of the jaws;
- are carefully retrieved to prevent excessive sample disturbance; and
- allow easy access to the sediment within the grab.

### **6.3 Sample Acceptability Criteria**

When the grab samplers have been secured on board, the hinged top flaps will be opened and the samples examined for acceptability. Acceptability criteria will include:

- the grabs are not overfilled to the point where there is evidence of sample loss around the access doors;
- overlying water is present, indicating minimal leakage;
- overlying water is not excessively turbid, indicating minimal sample disturbance; and
- a minimum acceptable sample penetration depth of at least 4 cm has been achieved.

Samples collected from the top 2 cm of sediment for sediment chemistry will require a minimum grab penetration depth of 4 cm. Care will be taken to extract sediment from the most undisturbed center portion of each grab without collecting sediment that has touched the sides of the grab. Penetration depth will be determined by measuring the depth of sediment within each grab by sliding a ruler vertically along the inside of the grab's side wall after each successful cast. Penetration depth can also be calculated by measuring the space between the sediment's surface within the grab and the top of the grab, then subtracting this vertical distance from 17 cm, the total inside height of the grab. Overlying water within the grab will be carefully siphoned off of the sediment surface for all acceptable samples.

### **6.4 Sample Processing**

Prior to any subsampling, a sediment aliquot will be collected for analysis of total sulfide. The total sulfide sample aliquot will always be collected from undisturbed sediment in one of the grabs using a stainless-steel spoon, and then placed directly in the appropriate sample container without homogenization. The remaining top 2 cm of undisturbed sediment in both grabs will be collected with a stainless-steel "cookie cutter" and spatula. This sediment will be placed in a stainless-steel bowl for homogenization, after which aliquots for the remaining analyses will be transferred to appropriate laboratory containers. Prior to homogenization, collected sediment will be stored covered with aluminum foil in coolers in the event that multiple grab deployments are required.

Head space will be left in all lab containers, with the exception of total sulfide, to allow further mixing at the laboratory and for expansion should the containers be stored frozen. All sample containers will be stored in insulated, ice-filled coolers while in the field. Total sulfide samples also require the use of a preservative. After the 4-ounce total sulfide lab container has been filled completely, 5 milliliters (ml) of 2N zinc acetate will be added to the top of the sediment prior to sealing the container. All sample containers, storage conditions, and hold times are summarized in Table 6-1.

**Table 6-1**  
**Sediment Chemistry Sample Containers, Storage Conditions, and Analytical Hold Times**

Analyte	Container	Preferred Storage Conditions	Hold Time	Acceptable Storage Conditions	Hold Time
Ammonia	4-oz. glass or polypropylene	refrigerate at 4°C	7 days to analyze	N/A	N/A
Particle Size Distribution	16-oz. glass or polypropylene	refrigerate at 4°C	6 months to analyze	N/A	N/A
Total Organic Carbon	4-oz. glass or polypropylene	freeze at -20°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Total Solids (collect w/ TOC)	4-oz. glass or polypropylene	freeze at -20°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Total Sulfide	4-oz. glass No Headspace	refrigerate at 4°C w/ 2N Zn acetate	7 days to analyze	N/A	N/A
Mercury	250-ml HDPE	freeze at -18°C	28 days to analyze	N/A	N/A
Other Metals	250-ml HDPE	freeze at -18°C	2 years to analyze	refrigerate at 4°C	6 months to analyze
BNAs	16-oz. glass	freeze at -18°C	1 year to extract 40 days to analyze	refrigerate at 4°C	14 days to extract 40 days to analyze
Butyltin Isomers	8-oz. glass	freeze at -18°C	1 year to extract 40 days to analyze	refrigerate at 4°C	14 days to extract 40 days to analyze
Pesticides/PCBs (collect w/ BNAs)	16-oz. glass	freeze at -18°C	1 year to extract 40 days to analyze	refrigerate at 4°C	14 days to extract 40 days to analyze
PBDEs (collect w/ BNAs)	16-oz. glass	freeze at -18°C	1 year to extract 40 days to analyze	refrigerate at 4°C	14 days to extract 40 days to analyze

### 6.5 Sampling Equipment Decontamination

The grab samplers will be decontaminated between sampling stations by scrubbing with a brush and ambient sea water, followed by a thorough *in situ* rinsing. A separate stainless steel bowl, cookie cutter, spatula, and spoon will be dedicated to each sampling station, precluding the need for decontamination of this equipment.

### 6.6 Sample Storage and Delivery

All sample containers will be stored in an insulated cooler containing ice immediately after collection to maintain the samples at a temperature of approximately 4° Celsius until delivery to the laboratory. Sample containers from each station will be grouped and placed in plastic bags to facilitate sample receipt and login. At the end of each sampling day, all samples will be transported back to the King County Environmental Laboratory.

### 6.7 Chain of Custody

Chain of custody (COC) will commence at the time that each sample is collected. While in the field, all samples will be under direct possession and control of King County field staff. For chain of custody purposes, the *Liberty* will be considered a “controlled area.” Each day, all sample information will be recorded on a COC form (Figure 2). This form will be completed in the field and will accompany all samples during transport and delivery to the laboratory each day. Upon arrival at the King County Environmental Laboratory, the sample delivery person will relinquish all samples to the sample login person. The date and time of sample delivery will be recorded and both parties will then sign off in the appropriate sections on the COC form at this time. Once completed, original COC forms will be archived in the project file.

Samples delivered after regular business hours will be stored in a locked chain of custody refrigerator until the next day. Samples delivered to a contracted laboratory will be accompanied by a properly-completed King County Environmental Laboratory COC form and custody seals will be placed on the cooler if samples are delivered by an outside courier. Contracted laboratories will be expected to provide a copy of the completed COC form as part of their analytical data package.

## **7 SAMPLE DOCUMENTATION**

Sampling information and sample metadata will be documented using the methods noted below.

- Field sheets generated by King County's Laboratory Information Management System (LIMS) that will include information such as:
  1. sample identification number
  2. station name
  3. station bottom depth
  4. sediment depth (i.e., sampler penetration depth) for each successful grab deployment
  5. physical sediment characteristics
  6. date and time of sample collection
  7. condition and height of tide
  8. name of all sampling personnel
- LIMS-generated container labels will identify each container with a unique sample number, station and site names, collect date, analyses required, and preservation method.
- The *Liberty's* logbook will contain records of all shipboard activities, destinations, arrival and departure times, general weather and positioning information, the names of shipboard personnel.
- The *Liberty's* cruise plan will list the prescribed stations to be sampled, along with their respective coordinates and other associated locating information.
- Electronic DGPS coordinate data will be electronically logged for each acceptable grab deployment, using both latitude/longitude and NAD 83 State Plane formats.
- COC documentation will consist of the King County Environmental Laboratory's standard COC form, which is used to track release and receipt of each sample from collection to arrival at the lab.

A sample of a typical field sheet used by the King County Environmental Laboratory is included as Figure 3.

## **8 FIELD MEASUREMENTS AND OBSERVATIONS**

The following field measurements and observations will be recorded on the appropriate field sheet/log for each sample:

- sample (bottom) depth - measured as keel depth by vessel's fathometer;
- sediment depth (grab penetration depth) - measured by ruler inside the grab;
- sediment sampling range (0 – 2 cm);

- sediment type (a mnemonic code indicating color, gross grain size, odor, and debris);
- tide condition and height;
- collect date, collect time, and sampling personnel; and
- general sample information such as sampling irregularities (e.g. inferior sample material due to the presence of rocks, debris, etc.).

## 9 ANALYTICAL PARAMETERS AND METHODS

Analytical parameters for sediment chemistry samples are presented in the following sections. All analyses will follow guidelines suggested in the Puget Sound Protocols (PSEP 1986, 1997b, and 1997c) and will be performed at the King County Environmental Laboratory.

The terms MDL and RDL, used in the following chemistry analysis sections, refer to *method detection limit* and *reporting detection limit*, respectively. The MDL is defined as *the minimum concentration of a chemical constituent that can be detected*, while the RDL is defined as *the minimum concentration of a chemical constituent that can be reliably quantified*. The MDL and RDL are based on routine method-concentration factors, assuming 50% total solids by weight.

### 9.1 Conventional – Analytical Methods and Detection Limits

Conventional sediment parameters will include ammonia, PSD, TOC, total solids, and total sulfides. The analytical methods and detection limits for conventional parameters are summarized in Table 9-1.

**Table 9-1**  
**Conventional Methods and Detection Limits**

Parameter	Method	MDL	RDL	Units <sup>1</sup>
Ammonia	SM 4500-NH3-G	0.2	0.4	mg/Kg dry wt.
PSD (gravel and sand)	ASTM D422	0.1	1.0	percent dry wt.
PSD (silt and clay)	ASTM D422	0.5	1.0	percent dry wt.
Total Organic Carbon	EPA 9060, PSEP 1996	1,000	2,000	mg/Kg dry wt.
Total Solids	SM 2540-G	0.005	0.01	percent wet wt.
Total Sulfide	EPA 9030B/SM 4500-S2-D	1.0	4.0	mg/Kg dry wt.

<sup>1</sup>Dry-weight MDLs for ammonia, TOC, and sulfide are based on an assumed 50% solids content.

Total solids will be analyzed on all samples to allow normalization of all other sediment chemistry data to dry weight. Total solids analysis will be performed according to the latest edition of Standard Method (SM)2540-G (APHA 1998), which is a gravimetric determination. Results for solids analyses are presented in units of percent on a wet-weight basis.

TOC analysis will be performed on all samples to allow normalization of some organic parameters to organic carbon. TOC analysis will be performed according to EPA Method 9060/SW-846 (EPA 1995), high-temperature combustion with infrared spectroscopy. Results for TOC analysis are presented in units of mg/Kg on a dry-weight basis.

PSD analysis will be performed according to ASTM Method D422 (ASTM 2002), which is a combination of sieve and hydrometer analyses. Results for PSD analysis are presented in

units of percent on a dry weight basis, both for phi sizes and for the four broad classifications of clay, silt, sand, and gravel. Results for the clay and silt fractions are also summed to provide a result for “percent fines.”

Ammonia and total sulfide, which are indicators of potential sediment toxicity, will be analyzed by SM 4500-NH3-G and SM 4500-S2-D (EPA 9030B), respectively. Ammonia analysis will involve a potassium chloride extraction followed by spectrometric analysis of the extract. Total sulfide will be analyzed by distillation following acidification and colorimetric analysis of the distillate.

## 9.2 Metals – Analytical Methods and Detection Limits

The analytical methods and detection limits for the target metals are summarized in Table 9-2. These MDLs and RDLs are presented on a wet-weight basis and are based on an initial sample weight of 1±0.05 grams (g) and a final volume of 50 milliliters (ml) for ICP metals and 100 ml for mercury. Mercury will be analyzed by cold vapor atomic absorption spectroscopy (CVAA) and other metals will be analyzed by inductively coupled plasma optical emission spectroscopy (ICP-OES) with a strong acid digestion.

**Table 9-2**  
**Metals Target Analytes, Methods,**  
**and Detection Limits (mg/Kg wet weight)**

Analyte	Method	MDL	RDL
Aluminum	EPA 3050B/6010C	5	25
Antimony	EPA 3050B/6010C	0.75	3.75
Arsenic	EPA 3050B/6010C	1.25	6.25
Cadmium	EPA 3050B/6010C	0.1	0.5
Chromium	EPA 3050B/6010C	0.15	0.75
Copper	EPA 3050B/6010C	0.2	1
Iron	EPA 3050B/6010C	2.5	12.5
Lead	EPA 3050B/6010C	1	5
Mercury	EPA 7471B	0.005	0.05
Nickel	EPA 3050B/6010C	0.25	1.25
Silver	EPA 3050B/6010C	0.2	1
Tin	EPA 3050B/6010C	1	5
Zinc	EPA 3050B/6010C	0.25	1.25

MDLs for 10 trace metals, normalized to dry weight over a range of percent solids concentrations, are shown in Appendix A (Table A-1). This information is provided to demonstrate whether dry-weight normalized MDLs for antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc will meet Ecology’s recommended Practical Quantitation Limits (PQLs) from the Sampling and Analysis Plan Appendix (SAPA) (Ecology 2008). The information in Table A-1 shows that dry-weight normalized MDLs for these 10 metals all meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75%.

## 9.3 Trace Organics – Analytical Methods and Detection Limits

Trace organic parameters will include BNAs, chlorinated pesticides, PCBs, butyltins, and PBDEs. The analytical methods and detection limits for the target BNA, chlorinated pesticide, and PCB compounds are summarized in Tables 9-3 through 9-5 on a wet-weight basis. Wet-weight MDLs are normalized to dry weight over a range of percent solids



contents in Appendix A (Tables A-2 through A-4) for comparison with practical quantitation limits (PQLs) recommended in Ecology's SAPA (Ecology 2008). The SAPA does not provide specific PQLs for butyltins and PBDEs, therefore, detection limits for these compounds are presented on a dry-weight basis, with an assumed 50% solids content, in Tables 9-6 and 9-7.

Results for certain non-ionizing organic compounds are generally normalized to organic carbon for comparison to SMS chemical criteria. The King County Environmental Laboratory has attempted to optimize its procedures to produce the lowest cost-effective MDLs that are routinely achievable in a standard sediment sample. These MDLs should meet the required SMS chemical criteria for each parameter in most cases. The ability of the laboratory to attain detection limits which meet organic-carbon normalized chemical criteria, however, will depend upon the TOC content of each sample. Organic-carbon normalized detection limits are shown in Table 9-8. These values are based on the wet-weight detection limits shown in Tables 9-3 and 9-5 and converted using a conservatively-low percent solids content of 35% and the minimum TOC content that would be applicable for organic-carbon normalization (0.5% by dry weight).

### 9.3.1 BNA Target Analytes and Detection Limits

The detection limits for the target BNA compounds are summarized in Table 9-3. These MDLs and RDLs are presented on a wet-weight basis and are based on a 40 g extraction with gel permeation cleanup and concentration to a final volume of 0.5 ml for analysis. Note that the detection limits can vary if limited sample is available for extraction (less than 30 g) or if dilution is required due to elevated analyte concentration(s). BNA analysis will be performed according to EPA methods 3550B/8270D (SW 846), which employ solvent extraction with sonication and analysis by gas chromatography/mass spectroscopy (GC/MS).

**Table 9-3**  
**BNA Target Analytes and Detection Limits (µg/Kg wet weight)**

Analyte	MDL	RDL	Analyte	MDL	RDL
1,2,4-Trichlorobenzene	0.27	0.53	Chrysene	2.7	5.3
1,2-Dichlorobenzene	0.27	0.53	Coprostanol	53	106
1,4-Dichlorobenzene	0.27	0.53	Dibenzo(a,h)anthracene	2.7	5.3
2,4-Dimethylphenol	2.7	5.3	Dibenzofuran	2.7	5.3
2-Methylnaphthalene	2.7	5.3	Diethyl Phthalate	5.3	10.6
2-Methylphenol	5.3	10.6	Dimethyl Phthalate	5.3	10.6
4-Methylphenol	5.3	10.6	Di-N-Butyl Phthalate	5.3	10.6
Acenaphthene	2.7	5.3	Di-N-Octyl Phthalate	5.3	10.6
Acenaphthylene	2.7	5.3	Fluoranthene	2.7	5.3
Anthracene	2.7	5.3	Fluorene	2.7	5.3
Benzo(a)anthracene	2.7	5.3	Hexachlorobenzene	0.53	1.06
Benzo(a)pyrene	2.7	5.3	Hexachlorobutadiene	1.3	2.6
Benzo(b)fluoranthene	2.7	5.3	Indeno(1,2,3-cd)pyrene	2.7	5.3
Benzo(g,h,i)perylene	2.7	5.3	Naphthalene	2.7	5.3
Benzo(k)fluoranthene	2.7	5.3	N-Nitrosodiphenylamine	5.3	10.6
Benzoic Acid	13	26	Pentachlorophenol	13.3	26.6
Benzyl Alcohol	5.3	10.6	Phenanthrene	2.7	5.3
Benzyl Butyl Phthalate	5.3	10.6	Phenol	5.3	10.6
Bis(2-Ethylhexyl) Phthalate	5.3	10.6	Pyrene	5.3	10.6
Caffeine	4	8	Total 4-Nonylphenol	5	10

MDLs for BNA compounds, normalized to dry weight over a range of percent solids concentrations, are shown in Appendix A (Table A-2). This information is provided to demonstrate whether dry-weight normalized MDLs for BNAs will meet Ecology's recommended PQLs. The information in Table A-2 shows that all dry-weight normalized MDLs for BNA compounds meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75%.

### 9.3.2 Chlorinated Pesticide and PCB Target Analytes and Detection Limits

The detection limits for the target chlorinated pesticides and PCB Aroclors<sup>®</sup> are summarized in Tables 9-4 and 9-5. These MDLs and RDLs are presented on a wet-weight basis and are based on a 20 g extraction with gel permeation cleanup and concentration to a final volume of 0.5 ml for PCB analysis and 2.5 ml for pesticides. Note that the detection limits can vary if limited sample is available for extraction (less than 30 g) or if dilution is required due to elevated analyte concentration(s). Chlorinated pesticide/PCB analysis will be performed according to EPA methods 3550B/8081A/8082 (SW 846), which employ solvent extraction with sonication and analysis by gas chromatography with electron capture detector (GC/ECD) and dual column confirmation.

**Table 9-4**  
**Chlorinated Pesticide Target Analytes and Detection Limits (µg/Kg wet weight)**

Analyte	MDL	RDL	Analyte	MDL	RDL
4,4'-DDD	1	2	Endosulfan II	1	2
4,4'-DDE	1	2	Endosulfan Sulfate	1	2
4,4'-DDT	1	2	Endrin	1	2
Aldrin	1	2	Endrin Aldehyde	1	2
Alpha-BHC	1	2	Gamma-BHC (Lindane)	1	2
Alpha-Chlordane	1	2	Gamma-Chlordane	1	2
Beta-BHC	1	2	Heptachlor	1	2
Delta-BHC	1	2	Heptachlor Epoxide	1	2
Dieldrin	1	2	Methoxychlor	5	10
Endosulfan I	1	2	Toxaphene	10	20

**Table 9-5**  
**PCB Target Analytes and Detection Limits (µg/Kg wet weight)**

Analyte	MDL	RDL	Analyte	MDL	RDL
Aroclor 1016	1.3	2.6	Aroclor 1248	1.3	2.6
Aroclor 1221	3.3	6.6	Aroclor 1254	1.3	2.6
Aroclor 1232	3.3	6.6	Aroclor 1260	1.3	2.6
Aroclor 1242	1.3	2.6			

MDLs for chlorinated pesticides and PCBs, normalized to dry weight over a range of percent solids concentrations, are shown in Appendix A (Tables A-3 and A-4). This information is provided to demonstrate whether dry-weight normalized MDLs for chlorinated pesticides and PCBs will meet Ecology's recommended PQLs. The information in Tables A-3 and A-4 shows that dry-weight normalized MDLs for chlorinated pesticides and PCB Aroclors meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75% with two exceptions. The dry-weight normalized MDLs for Aroclors 1221 and 1232 at 25% and 50% solids exceed the SAPA-recommended PQL of 6 µg/Kg DW. This should not prove problematic, however, since the highest dry-weight normalized MDL of 13 µg/Kg DW is still

a factor of 10 lower than the LAET of 130 µg/Kg DW. Dry-weight normalized MDLs for several chlorinated pesticides exceed the SAPA-recommended PQLs at the 25-50% solids range. The dry-weight normalized MDL for Heptachlor exceeds the LAET over the full range of percent solids. The dry-weight normalized MDL for Dieldrin exceeds the LAET at the 25-50% solids range. The dry-weight normalized MDL for Chlordane exceeds the LAET at the 25% solids range.

### 9.3.3 Butyltin Target Analytes and Detection Limits

The detection limits for target butyltin isomers are summarized in Table 9-6. These MDLs and RDLs are presented on a dry-weight basis (assumed 50% solids content) and are based on a 20-g extraction with derivatization and silica gel/alumina cleanup and concentration to a final volume of 5 ml for analysis. Note that the detection limits can vary if limited sample is available for extraction (less than 20 g) or if dilution is required due to elevated analyte concentration(s). Butyltin analysis will be performed according to a National Oceanic and Atmospheric Administration method (Krone et al. 1989), which employs a methylene chloride extraction with tumbling, followed by derivatization through a Grignard reaction, and analysis by GC/ICPMS.

**Table 9-6**  
**Butyltin Isomer Target Analytes and Detection Limits (µg/Kg dry weight)**

Analyte	MDL	RDL	Analyte	MDL	RDL
Mono-n-butyltin	16.8	33.6	Tri-n-butyltin	2.0	4.1
Di-n-butyltin	3.5	7.0	Tetra-n-butyltin	4.0	8.0

### 9.3.4 PBDE Target Analytes and Detection Limits

The detection limits for target PBDE congeners are summarized in Table 9-7. These MDLs and RDLs are presented on a dry-weight basis (assumed 50% solids content) and are based on a 15-g extraction with GPC cleanup and concentration to a final volume of 1 ml for analysis. Note that the detection limits can vary if limited sample is available for extraction (less than 15 g) or if dilution is required due to elevated analyze concentration(s). PBDE analysis will be performed according to EPA method 3550B (SW-846) and King County standard operating procedure (SOP) #7-03-025-000 (King County 2006), which employ solvent extraction with sonication and analysis by GC-ICPMS.

**Table 9-7**  
**PBDE Target Analytes and Detection Limits (µg/Kg dry weight)**

Analyte	MDL	RDL	Analyte	MDL	RDL
PBDE-17	0.04	0.086	PBDE-100	0.040	0.086
PBDE-28	0.04	0.086	PBDE-138	0.040	0.086
PBDE-47	0.04	0.086	PBDE-153	0.040	0.086
PBDE-66	0.04	0.086	PBDE-154	0.040	0.086
PBDE-71	0.04	0.086	PBDE-183	0.040	0.086
PBDE-85	0.04	0.086	PBDE-190	0.040	0.086
PBDE-99	0.04	0.086	PBDE-209	0.20	0.41

### 9.3.5 Organic Carbon Normalized Detection Limits

Table 9-8 presents the organic-carbon normalized detection limits for the non-ionizable organic compounds regulated under the SMS, based on a percent solids concentration of 35% and a TOC content of 0.5%.

**Table 9-8**  
**Non-Ionizable Organic Compound Detection Limits (mg/Kg OC)**

Analyte	MDL	RDL	Analyte	MDL	RDL
2-Methylnaphthalene	1.5	3	Pyrene	3	6.1
Acenaphthene	1.5	3	1,2,4-Trichlorobenzene	0.15	0.3
Acenaphthylene	1.5	3	1,2-Dichlorobenzene	0.15	0.3
Anthracene	1.5	3	1,4-Dichlorobenzene	0.15	0.3
Benzo(a)anthracene	1.5	3	Hexachlorobenzene	0.3	0.63
Benzo(a)pyrene	1.5	3	Benzyl Butyl Phthalate	3	6.1
Benzo(b)fluoranthene	1.5	3	Diethyl Phthalate	3	6.1
Benzo(g,h,i)perylene	1.5	3	Dimethyl Phthalate	3	6.1
Benzo(k)fluoranthene	1.5	3	Di-N-Butyl Phthalate	3	6.1
Chrysene	1.5	3	Bis(2-Ethylhexyl) Phthalate	3	6.1
Dibenzo(a,h)anthracene	1.5	3	Di-N-Octyl Phthalate	3	6.1
Fluoranthene	1.5	3	Dibenzofuran	1.5	3
Fluorene	1.5	3	Hexachlorobutadiene	0.74	1.5
Indeno(1,2,3-cd)pyrene	1.5	3	N-Nitrosodiphenylamine	3	6.1
Naphthalene	1.5	3	PCBs (1016, 1242, 1248, 1254, 1260)	0.74	1.5
Phenanthrene	1.5	3	PCBs (1221, 1232)	1.9	3.8

All of the organic carbon normalized MDLs shown in Table 9-10 are below their respective SQS chemical criteria from Table I of Chapter 173-204 WAC (Ecology 1995).

## 10 LABORATORY QA/QC

The quality control (QC) samples that will be analyzed in association with sediment chemistry samples are summarized in Table 10-1. The frequency of method blanks, duplicates, triplicates, and matrix spikes is one per QC batch (20 samples maximum). The frequency of SRM (standard reference material) or LCS (laboratory control sample) analysis is one per project (40 samples maximum). LCS analysis is used in lieu of SRM analysis for selected analytes when an SRM may not be readily available. Surrogates are analyzed with every organic sample.

**Table 10-1**  
**Marine Sediment Chemistry Quality Control Samples**

Analyte	Method Blank	Spiked Blank	Duplicate/Triplicate	Matrix Spike (MS)	MS Duplicate	SRM/LCS	Surrogates
Ammonia	Yes	Yes	Triplicate	Yes	No	Yes	No
PSD	No	No	Triplicate	No	No	No	No
TOC	Yes	Yes	Triplicate	Yes	No	Yes	No
Total Solids	Yes	No	Triplicate	No	No	No	No
Total Sulfide	Yes	Yes	Triplicate	Yes	No	No	No
Mercury	Yes	Yes	Duplicate	Yes	Yes	Yes	No
Other Metals	Yes	Yes	Duplicate	Yes	No	Yes	No
BNAs	Yes	No	Duplicate	Yes	Yes	Yes	Yes
Butyltins	Yes	Yes	Duplicate	Yes	Yes	Yes	Yes
Chl. Pesticides	Yes	Yes	Duplicate	Yes	Yes	Yes	Yes
PCBs	Yes	Yes	Duplicate	Yes	Yes	Yes	Yes
PBDEs	Yes	Yes	Duplicate	Yes	Yes	No	Yes

Quality assurance (QA1) marine sediment chemistry acceptance criteria (Ecology 1989) are shown in Table 10-2.

**Table 10-2**  
**QA1 Acceptance Criteria for Marine Sediment Chemistry Samples**

Analyte	Method Blank	Spiked Blank	Duplicate/Triplicate	Matrix Spike	SRM/LCS	Surrogates
Ammonia	< MDL	80 – 120%	RSD ≤ 20%	75 - 125%	80 – 120%	N/A
PSD	N/A	N/A	RSD ≤ 20%	N/A	N/A	N/A
TOC	< MDL	80 - 120%	RSD ≤ 20%	75 - 125%	80 - 120%	N/A
Total Solids	< MDL	N/A	RSD ≤ 20%	N/A	N/A	N/A
Total Sulfide	< MDL	80 - 120%	RSD ≤ 20%	65 - 135%	N/A	N/A
Metals (incl. Hg)	< MDL	85 – 115%	RPD ≤ 20%	75 - 125%	Appendix B	N/A
BNAs	< MDL	Appendix B	RPD ≤ 35%	Appendix B	Appendix B	Appendix B
Butyltins	< MDL	Appendix B	RPD ≤ 35%	Appendix B	Appendix B	Appendix B
Chl. Pesticides	< MDL	Appendix B	RPD ≤ 35%	Appendix B	Appendix B	Appendix B
PCBs	< MDL	Appendix B	RPD ≤ 35%	Appendix B	Appendix B	Appendix B
PBDEs	< MDL	50 – 150%	RPD ≤ 35%	50 – 150%	N/A	50 – 150%

< MDL - Method Blank result should be less than the *method detection limit*.

RPD – Relative Percent Difference, RSD – Relative Standard Deviation

QC results for matrix spike, SRM/LCS, and surrogates are in *percent recovery of analyte*.

Some trace metal and organic analyses have empirically-derived laboratory limits for various QC samples. Specific laboratory-derived acceptance limits for trace metal and organic analyses are included as Appendix B (Tables B1 – B11). QC results that exceed the acceptance limits will be evaluated to determine appropriate corrective actions. Samples will typically be reanalyzed if the unacceptable QC results indicate a systematic problem with the overall analysis. Unacceptable QC results caused by a particular sample or matrix will not require reanalysis unless an allowed method modification would improve the results.

Analytical results that do not meet QA1 acceptance criteria will be qualified and flagged according to Ecology guidance (Ecology 2008).

## **11 DATA REPORTING AND RECORD KEEPING**

This section provides information on how monitoring data will be reported and interpreted and how project records will be maintained.

### **11.1 Analytical Data**

All sediment chemistry data will be reported in QA1 format (Ecology 1989). The final QA1 report will contain the following information and deliverables:

- a QA1 narrative discussing data quality in relation to study objectives and data criteria;
- all associated QC data (LIMS QC reports and worklists);
- copies of field sheets and COC forms; and
- a comprehensive report containing all analytical and field data (including data qualifier flags).

### **11.2 Final Report and EIMS Files**

A final monitoring report will be prepared that will include a presentation and interpretation of the sediment chemistry results. The report will compare sediment chemistry results to published sediment quality chemical criteria (Ecology 1995, EPA1988) as well as regional Puget Sound values in order to provide an evaluation of sediment quality in Elliott Bay. The chemistry data will be also reported in the regional Environmental Information Management System (EIMS) format for delivery to Ecology.

### **11.3 Record Keeping**

All field and sampling records, custody documents, raw lab data, and summaries and narratives will be archived according to King County Environmental Laboratory policy, for a minimum of 10 years from the date samples were collected. Interpretive reports and memoranda, along with all chemistry data, data analysis project narratives, and reports will be stored in project files for a minimum of 10 years from the date samples were collected. Appendix C includes LIMS “product names” and “list types” under which analytical data will be stored.

## **12 PROJECT HEALTH AND SAFETY**

The following general health and safety guidelines have been provided in lieu of a site-specific Health and Safety Plan. These guidelines will be read and understood by all members of the sampling crew.

- All crew of the research vessel will have received annual vessel safety training which will include proper chain of communication, equipment operation, and safe boating practices.
- Samplers will wear chemical-resistant gloves when coming into contact with sediment.
- No eating or drinking by sampling personnel will be allowed during active sampling operations.
- All sampling operations will be conducted during daylight hours.
- All accidents, ‘near misses,’ and symptoms of possible exposure will be reported to a crew member’s supervisor within 24 hours of occurrence.
- All crew members will be aware of the potential hazards associated with any chemicals used during the sampling effort.

Several hazards are inherent to marine sediment sampling. General vessel safety, physical hazards unique to sediment grab sampling, and chemical hazards are discussed in sections 12.1 through 12.3.

### **12.1 General Vessel Safety**

To help prevent accidents and ensure adequate preparation for emergencies that may possibly arise, the following safety equipment will be required on the *Liberty*:

- one personal floatation device for each crew member as well as at least one throwable floatation device;
- an accessible, clearly labeled, fully stocked first-aid/CPR kit;
- an accessible and clearly-labeled eye wash (when sampling suspected contaminated sediments);
- one (preferably two) VHF marine radio(s) with weather channel;
- a cellular telephone;
- a horn;
- navigation lights;
- an emergency life raft with oars or paddles;
- an anchor and suitable line;
- signal flares; and
- a reach pole or shepherd's hook.

Personal protective equipment will be selected and used that will protect workers involved in sediment sampling from the hazards and potential hazards likely to be encountered. Minimum required personal protective equipment for marine sediment sampling shall include the following:

- hard hat;
- steel-toe rubber boots;
- chemical-resistant gloves (e.g. Nitrile); and
- safety glasses.

Recommended additional personal protective equipment will include rain gear and hearing protection when the *Liberty* is under way.

### **12.2 Grab Sampling**

Sampler deployment and sediment retrieval present physical hazards due, in part, to the heavy weight of the grab sampler, its suspension above the vessel deck, and the risk of accidental or premature closure. Prior to each sampling event, all cabling, shackles, pins, housings, and swivels will be inspected to ensure the integrity of all points along the sampling assembly.

The sampler will always be set while it is resting on a stable surface. Once set, a safety pin will be set in place on the triggering mechanism and remain in place until the sampler is swung outboard of the vessel rail. Special care will be exercised when removing the safety pin to ensure personal safety in the event of a gear or winch failure. Fingers will not be placed through the ring of the pin when it is removed and hands will be kept completely clear of the sampler interior after the pin has been removed. If a sampler is retrieved that has not been tripped, it will be lowered to a stable surface before any worker contact.

During grab retrieval, one crew member will watch for the appearance of the grab sampler and alert the winch operator when the sampler is first visible below the water surface. Attempting to bring a swinging grab sampler on board poses a serious risk of being hit or knocked overboard. The winch operator will minimize swinging before the grab sampler is brought on board for the crew to secure. Hard hats and gloves will always be worn when handling the grab sampler.

The winch drum, blocks, capstan, and any area between the grab sampler and railings, the deck, and heavy equipment all represent significant pinching and crushing hazards. Only experienced crew members will operate the winch or capstan during a sampling event. Other crew members will exercise care to avoid these potentially hazardous areas.

### **12.3 Chemical Hazards**

Contact with marine sediment at some sampling stations, especially within Elliott Bay, may present a health hazard from chemical constituents of the sediment, such as PCBs, mercury, phthalates, and PAHs. Potential routes of exposure to chemical hazards include **inhalation, skin and eye absorption, ingestion, and injection**. Crew members will exercise caution to avoid coming into contact with sediment at all stations during sampling operations.

Protective equipment will include chemical-resistant gloves, safety glasses or goggles, and protective clothing (e.g. rain gear). Crew members will exercise good personal hygiene after sampling and prior to eating or drinking.



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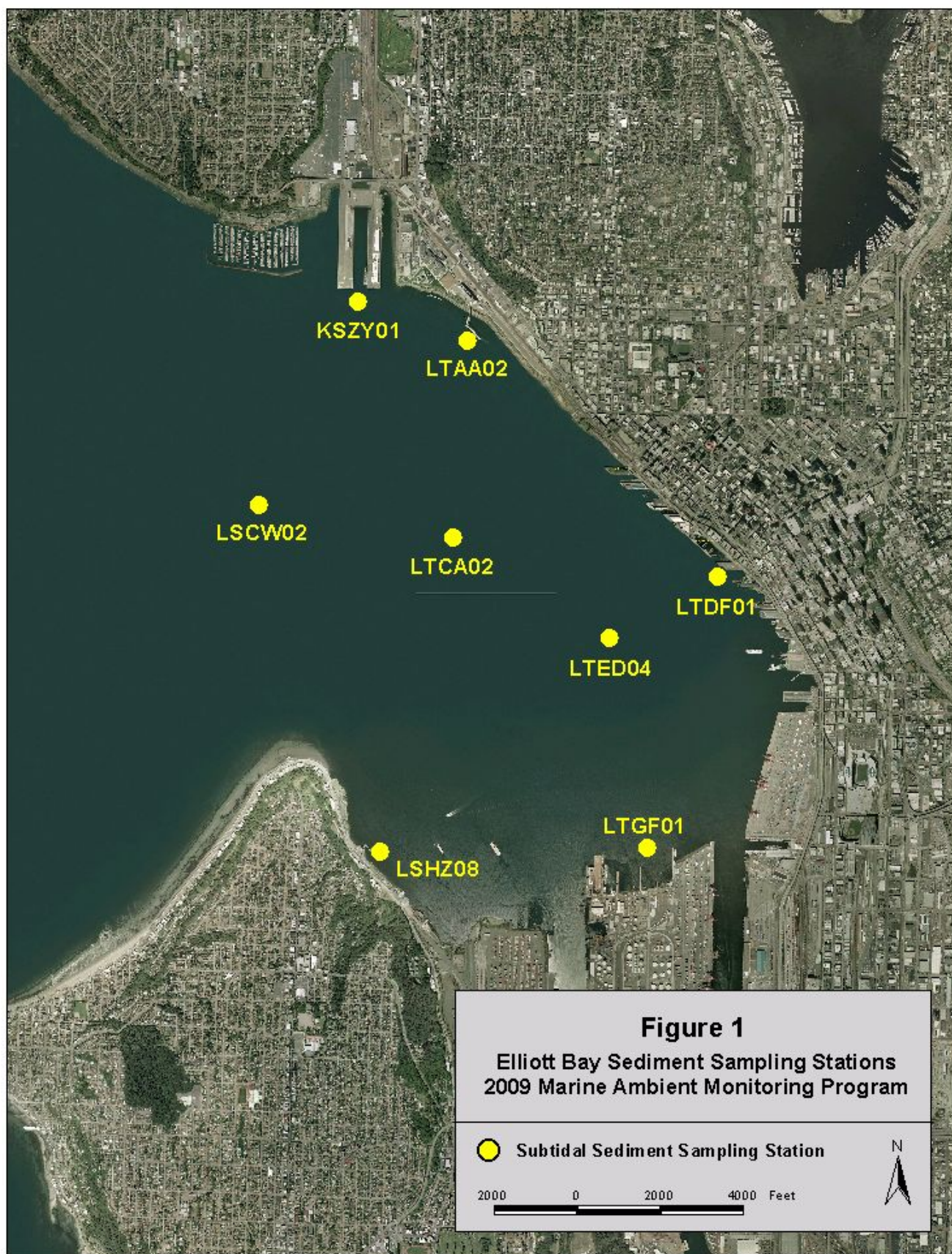
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## FIGURES



## KING COUNTY ENVIRONMENTAL LABORATORY CHAIN OF CUSTODY FORM

[illegible]

# FIGURE 3

## KING COUNTY ENVIRONMENTAL LABORATORY STANDARD FIELD SHEET

Fieldsheet ID: 421235\_22JUN1999\_101133

Page: 1

MAJOR LAKES (wtr col)

Project Number: 421235

Personnel: \_\_\_\_\_

Sample Number	P15790-1	P15790-2	P15790-3	
Locator	0618	0623	0625	
Short Loc. Desc.		Rosemnt SD	Sammslough	
Locator Desc.		LAKE SAMM/WEST SHORE-ROSEMONT STOR	Lake Sammamish	
Site	MAJOR LAKES	MAJOR LAKES	MAJOR LAKES	
Sample Depth				
Collect Date				
Comments				
EH, FIELD				
SED DEPTH				
SED SAMP RANGE				
SED TYPE				
TIME				
Dept., Matrix, Prod				
	3   FRSHWTRSED   AVS	3   FRSHWTRSED   AVS	3   FRSHWTRSED   AVS	
	3   FRSHWTRSED   NH3	3   FRSHWTRSED   NH3	3   FRSHWTRSED   NH3	
	3   FRSHWTRSED   PSD	3   FRSHWTRSED   PSD	3   FRSHWTRSED   PSD	
	3   FRSHWTRSED   TOC	3   FRSHWTRSED   TOC	3   FRSHWTRSED   TOC	
	3   FRSHWTRSED   TOTP	3   FRSHWTRSED   TOTP	3   FRSHWTRSED   TOTP	
	3   FRSHWTRSED   TOTS	3   FRSHWTRSED   TOTS	3   FRSHWTRSED   TOTS	
	3   FRSHWTRSED   TOTSULFIDE	3   FRSHWTRSED   TOTSULFIDE	3   FRSHWTRSED   TOTSULFIDE	
	6   FRSHWTRSED   HG-CVAA	6   FRSHWTRSED   HG-CVAA	6   FRSHWTRSED   HG-CVAA	
	6   FRSHWTRSED   PP ICPMS	6   FRSHWTRSED   PP ICPMS	6   FRSHWTRSED   PP ICPMS	
	7   FRSHWTRSED   BNA	7   FRSHWTRSED   BNA	7   FRSHWTRSED   BNA	
	7   FRSHWTRSED   CHLOROBENZENES	7   FRSHWTRSED   CHLOROBENZENES	7   FRSHWTRSED   CHLOROBENZENES	
	7   FRSHWTRSED   CLPESTPCB	7   FRSHWTRSED   CLPESTPCB	7   FRSHWTRSED   CLPESTPCB	
	7   FRSHWTRSED   HERB	7   FRSHWTRSED   HERB	7   FRSHWTRSED   HERB	
	7   FRSHWTRSED   OPPEST	7   FRSHWTRSED   OPPEST	7   FRSHWTRSED   OPPEST	
	7   FRSHWTRSED   TRIBUTYLtin	7   FRSHWTRSED   TRIBUTYLtin	7   FRSHWTRSED   TRIBUTYLtin	
	7   FRSHWTRSED   WTPH-HCID	7   FRSHWTRSED   WTPH-HCID	7   FRSHWTRSED   WTPH-HCID	

End of Fieldsheet.

## **APPENDIX A**

**Metals and Trace Organics Dry-Weight Normalized Method Detection Limits (MDLs)  
Compared to Recommended Practical Quantitation Limits (PQLs)**

**Tables A-1 through A-4**

**Table A-1**  
**Dry-Weight Normalized MDLs for Trace Metals**  
**Compared to SAPA PQLs (all values in mg/Kg)**

Trace Metal	WW MDL	DW MDL 25%	DW MDL 50%	DW MDL 75%	DW SAPA PQL
Antimony	0.75	3	1.5	1	50
Arsenic	1.25	5	2.5	1.7	19
Cadmium	0.1	0.4	0.2	0.13	1.7
Chromium	0.15	0.6	0.3	0.2	87
Copper	0.2	0.8	0.4	0.27	130
Lead	1	4	2	1.3	150
Mercury	0.005	0.02	0.01	0.0067	0.14
Nickel	0.25	1	4	1.7	47
Silver	0.2	0.8	0.4	0.27	2
Zinc	0.25	1	0.5	0.33	137

WW MDL – Nominal wet-weight method detection limit from Table 9-2.

DW MDL – Dry-weight normalized method detection limit based on percent solids content of 25, 50, and 75%.

DW SAPA PQL – Recommended practical quantitation limit from Sampling and Analysis Plan Appendix (Ecology 2008).

**All dry-weight normalized MDLs for Trace Metals meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75%.**



**Table A-2**  
**Dry-Weight Normalized MDLs for BNAs**  
**Compared to SAPA PQLs (all values in µg/Kg)**

BNA	WW MDL	DW MDL 25%	DW MDL 50%	DW MDL 75%	DW SAPA PQL
1,2,4-Trichlorobenzene	0.27	1.1	0.54	0.36	31
1,2-Dichlorobenzene	0.27	1.1	0.54	0.36	35
1,4-Dichlorobenzene	0.27	1.1	0.54	0.36	37
2,4-Dimethylphenol	2.7	11	5.4	3.6	29
2-Methylnaphthalene	2.7	11	5.4	3.6	223
2-Methylphenol	5.3	21	11	7.1	63
4-Methylphenol	5.3	21	11	7.1	223
Acenaphthene	2.7	11	5.4	3.6	167
Acenaphthylene	2.7	11	5.4	3.6	433
Anthracene	2.7	11	5.4	3.6	320
Benzo(a)anthracene	2.7	11	5.4	3.6	433
Benzo(a)pyrene	2.7	11	5.4	3.6	533
Benzo(b)fluoranthene	2.7	11	5.4	3.6	1,067
Benzo(g,h,i)perylene	2.7	11	5.4	3.6	223
Benzo(k)fluoranthene	2.7	11	5.4	3.6	1,067
Benzoic Acid	13	52	26	17	217
Benzyl Alcohol	5.3	21	11	7.1	57
Benzyl Butyl Phthalate	5.3	21	11	7.1	21
Bis(2-Ethylhexyl) Phthalate	5.3	21	11	7.1	433
Caffeine	4.0	16	8	5.2	--
Chrysene	2.7	11	5.4	3.6	467
Coprostanol	53	210	110	71	--
Dibenzo(a,h)anthracene	2.7	11	5.4	3.6	77
Dibenzofuran	2.7	11	5.4	3.6	180
Diethyl Phthalate	5.3	21	11	7.1	67
Dimethyl Phthalate	5.3	21	11	7.1	24
Di-N-Butyl Phthalate	5.3	21	11	7.1	467
Di-N-Octyl Phthalate	5.3	21	11	7.1	2,067
Fluoranthene	2.7	11	5.4	3.6	567
Fluorene	2.7	11	5.4	3.6	180
Hexachlorobenzene	0.53	2.1	1.1	0.71	22
Hexachlorobutadiene	1.3	5.2	2.6	1.7	11
Indeno(1,2,3-cd)pyrene	2.7	11	5.4	3.6	200
Naphthalene	2.7	11	5.4	3.6	700
N-Nitrosodiphenylamine	5.3	21	11	7.1	28
Pentachlorophenol	13	52	26	17	120
Phenanthrene	2.7	11	5.4	3.6	500
Phenol	5.3	21	11	7.1	140
Pyrene	5.3	21	11	7.1	867
Total 4-Nonylphenol	5.0	20	10	6.7	--

WW MDL – Nominal wet weight method detection limit from Table 9-3.

DW MDL – Dry-weight normalized method detection limit based on percent solids content of 25, 50, and 75%.

DW SAPA PQL – Recommended practical quantitation limit from Sampling and Analysis Plan Appendix (Ecology 2008).

**All dry-weight normalized MDLs for BNA compounds meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75%.**

**Table A-3**  
**Dry-Weight Normalized MDLs for Chlorinated Pesticides**  
**Compared to SAPA PQLs (all values in µg/Kg)**

<b>Pesticide</b>	<b>WW MDL</b>	<b>DW MDL 25%</b>	<b>DW MDL 50%</b>	<b>DW MDL 75%</b>	<b>DW SAPA PQL</b>
4,4'-DDD	1	4	2	1.3	3.3
4,4'-DDE	1	4	2	1.3	2.3
4,4'-DDT	1	4	2	1.3	6.7
Aldrin	1	4	2	1.3	1.7
Alpha-BHC	1	4	2	1.3	--
Alpha-Chlordane	1	4	2	1.3	1.7
Beta-BHC	1	4	2	1.3	--
Delta-BHC	1	4	2	1.3	--
Dieldrin	1	4	2	1.3	2.3
Endosulfan I	1	4	2	1.3	--
Endosulfan II	1	4	2	1.3	--
Endosulfan Sulfate	1	4	2	1.3	--
Endrin	1	4	2	1.3	--
Endrin Aldehyde	1	4	2	1.3	--
Gamma-BHC (Lindane)	1	4	2	1.3	1.7
Gamma-Chlordane	1	4	2	1.3	1.7
Heptachlor	1	4	2	1.3	1.7
Heptachlor Epoxide	1	4	2	1.3	--
Methoxychlor	5	20	10	6.7	--
Toxaphene	10	40	20	13.3	--

WW MDL – Nominal wet weight method detection limit from Table 9-4.

DW MDL – Dry-weight normalized method detection limit based on percent solids content of 25, 50, and 75%.

DW SAPA PQL – Recommended practical quantitation limit from Sampling and Analysis Plan Appendix (Ecology 2008).

Dry-weight normalized MDLs for chlorinated pesticides meet the SAPA-recommended PQLs at the 75% solids range for all compounds. At the 50% solids range, the dry-weight normalized MDLs for Aldrin, Alpha-Chlordane, Gamma-BHC, Gamma-Chlordane, and Heptachlor are greater than the SAPA-recommended PQLs. At the 25% solids range, all dry-weight normalized MDLs for chlorinated pesticides exceed the SAPA-recommended PQL with the exception of 4,4'-DDT.

**Table A-4**  
**Dry-Weight Normalized MDLs for PCBs**  
**Compared to SAPA PQLs (all values in µg/Kg)**

<b>PCB</b>	<b>WW MDL</b>	<b>DW MDL 25%</b>	<b>DW MDL 50%</b>	<b>DW MDL 75%</b>	<b>DW SAPA PQL</b>
Aroclor 1016	1.3	5.2	2.6	1.7	6
Aroclor 1221	3.3	13	6.6	4.4	6
Aroclor 1232	3.3	13	6.6	4.4	6
Aroclor 1242	1.3	5.2	2.6	1.6	6
Aroclor 1248	1.3	5.2	2.6	1.7	6
Aroclor 1254	1.3	5.2	2.6	1.7	6
Aroclor 1260	1.3	5.2	2.6	1.7	6

WW MDL – Nominal wet weight method detection limit from Table 9-5.

DW MDL – Dry-weight normalized method detection limit based on percent solids content of 25, 50, and 75%.

DW SAPA PQL – Recommended practical quantitation limit from Sampling and Analysis Plan Appendix (Ecology 2008).

Dry-weight normalized MDLs for PCB Aroclors meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75% with two exceptions. The dry-weight normalized MDLs for Aroclors 1221 and 1232 at 25% and 50% solids exceed the SAPA-recommended PQL of 6 µg/Kg DW.

## **APPENDIX B**

### **Metals and Trace Organics Performance-Based QC Limits**

**Tables B-1 through B-11**

**Table B-1a****Laboratory QC Limits for Sediment Metals – SRM Recoveries (PACS-2)**

Parameter	Lower Limit (%)	Upper Limit (%)
Chromium	30	70
Copper	78	118
Lead	74	114
Mercury	80	120
Nickel	51	91
Zinc	73	113

**Table B-1b****Laboratory QC Limits for Sediment Metals – LCS Recoveries (ERA Soil)**

Parameter	Lower Limit (%)	Upper Limit (%)
Antimony	80	120
Arsenic	80	120
Cadmium	80	120
Chromium	80	120
Copper	80	120
Lead	80	120
Nickel	80	120
Silver	80	120
Zinc	80	120

No QA1 flagging occurs as a result of LCS recoveries being outside of control limits.

**Table B-2****Laboratory QC Limits for Sediment BNAs, Matrix Spike Recoveries**

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
1,2,4-Trichlorobenzene	10	115	Chrysene	14	184
1,2-Dichlorobenzene	10	105	Coprostanol	10	183
1,3-Dichlorobenzene	10	103	Di-N-Butyl Phthalate	10	194
1,4-Dichlorobenzene	10	104	Di-N-Octyl Phthalate	52	151
2,4-Dimethylphenol	10	150	Dibenzo(a,h)anthracene	10	166
2-Methylnaphthalene	22	112	Dibenzofuran	21	134
2-Methylphenol	10	142	Diethyl Phthalate	31	150
4-Methylphenol	10	163	Dimethyl Phthalate	13	162
Acenaphthene	25	130	Fluoranthene	12	188
Acenaphthylene	27	132	Fluorene	22	147
Anthracene	10	181	Hexachlorobenzene	18	151
Benzo(a)anthracene	32	168	Hexachlorobutadiene	10	97
Benzo(a)pyrene	10	200	Hexachloroethane	10	89
Benzo(b)fluoranthene	10	199	Indeno(1,2,3-Cd)Pyrene	10	177
Benzo(g,h,i)perylene	10	173	N-Nitrosodiphenylamine	10	169
Benzo(k)fluoranthene	10	192	Naphthalene	12	97
Benzoic Acid	10	158	Pentachlorophenol	17	170
Benzyl Alcohol	10	138	Phenanthrene	10	200
Benzyl Butyl Phthalate	41	145	Phenol	10	127
Bis(2-Ethylhexyl)Phthalate	10	189	Pyrene	20	174

**Table B-3**  
**Laboratory QC Limits for Sediment BNAs, Blank Spike Recoveries**

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
1,2,4-Trichlorobenzene	13	110	Chrysene	69	111
1,2-Dichlorobenzene	10	116	Coprostanol	10	159
1,3-Dichlorobenzene	18	95	Di-N-Butyl Phthalate	17	180
1,4-Dichlorobenzene	21	99	Di-N-Octyl Phthalate	10	200
2,4-Dimethylphenol	10	81	Dibenzo(a,h)anthracene	53	129
2-Methylnaphthalene	22	99	Dibenzofuran	37	97
2-Methylphenol	16	91	Diethyl Phthalate	51	118
4-Methylphenol	10	125	Dimethyl Phthalate	38	114
Acenaphthene	29	102	Fluoranthene	55	132
Acenaphthylene	31	101	Fluorene	39	106
Anthracene	45	114	Hexachlorobenzene	40	111
Benzo(a)anthracene	69	117	Hexachlorobutadiene	10	97
Benzo(a)pyrene	15	137	Hexachloroethane	17	92
Benzo(b)fluoranthene	50	121	Indeno(1,2,3-Cd)Pyrene	51	132
Benzo(g,h,i)perylene	46	126	N-Nitrosodiphenylamine	11	148
Benzo(k)fluoranthene	58	128	Naphthalene	17	94
Benzoic Acid	10	170	Pentachlorophenol	38	124
Benzyl Alcohol	10	119	Phenanthrene	57	104
Benzyl Butyl Phthalate	15	183	Phenol	10	107
Bis(2-Ethylhexyl)Phthalate	10	182	Pyrene	48	132

**Table B-4**  
**Laboratory QC Limits for Sediment BNAs, Surrogate Recoveries**

Parameter	Lower Limit (%)	Upper Limit (%)
2,4,6-Tribromophenol	29	112
2-Fluorophenol	10	112
d5-Phenol	10	106
d5-Nitrobenzene	28	94
d4-2-Chlorophenol	11	105
d4-1,2-Dichlorobenzene	24	91
2-Fluorobiphenyl	31	101
d14-Terphenyl	51	130

**Table B-5**  
**Laboratory QC Limits for Sediment BNAs, SRM Recoveries**

Parameter	Lower Limit (%)	Upper Limit (%)
Anthracene	28	98
Benzo(a)anthracene	66	124
Benzo(a)pyrene	60	116
Benzo(b)fluoranthene	52	190
Benzo(g,h,i)perylene	15	121
Benzo(k)fluoranthene	60	146
Chrysene	77	136
Dibenzo(a,h)anthracene	10	200
Fluoranthene	45	126
Indeno(1,2,3-Cd)Pyrene	33	121
Naphthalene	10	29
Phenanthrene	51	106
Pyrene	36	135

**Table B-6**  
**Laboratory QC Limits for Sediment Pesticides and PCBs**  
**Matrix Spike Recoveries**

Parameter	Lower Limit (%)	Upper Limit (%)
4,4'-DDD	41	157
4,4'-DDE	59	125
4,4'-DDT	50	144
Aldrin	61	119
Alpha-BHC	59	111
Aroclor 1016	32	164
Aroclor 1260	28	144
Beta-BHC	60	119
Delta-BHC	54	126
Dieldrin	60	139
Endosulfan I	64	113
Endosulfan II	36	146
Endosulfan Sulfate	46	113
Endrin	62	166
Endrin Aldehyde	10	66
Gamma-BHC (Lindane)	61	135
Heptachlor	52	157
Heptachlor Epoxide	61	118
Methoxychlor	53	129

**Table B-7**  
**Laboratory QC Limits for Sediment Pesticides and PCBs**  
**Blank Spike Recoveries**

Parameter	Lower Limit (%)	Upper Limit (%)
4,4'-DDD	78	121
4,4'-DDE	75	111
4,4'-DDT	57	145
Aldrin	28	113
Alpha-BHC	20	99
Aroclor 1016	39	121
Aroclor 1260	53	140
Beta-BHC	66	102
Delta-BHC	63	108
Dieldrin	58	139
Endosulfan I	62	104
Endosulfan II	72	109
Endosulfan Sulfate	61	104
Endrin	60	160
Endrin Aldehyde	0	77
Gamma-BHC (Lindane)	27	130
Heptachlor	20	137
Heptachlor Epoxide	59	107
Methoxychlor	72	131

**Table B-8**  
**Laboratory QC Limits for Sediment Pesticides and PCBs**  
**SRM and Surrogate Recoveries**

Parameter	Lower Limit (%)	Upper Limit (%)
4,4'-DDT	10	200
Alpha-Chlordane	48	144
Aroclor 1254	57	139
Decachlorobiphenyl	15	155
2,4,5,6-Tetrachloro-m-xylene	30	134

**Table B-9**  
**Laboratory QC Limits for Sediment Butyltins**  
**Matrix Spike Recoveries**

Parameter	Lower Limit (%)	Upper Limit (%)
Tetra-n-butyltin (as tetrabutyltin)	54	130
Tri-n-butyltin (as tributyltin)	57	119
Di-n-butyltin (as dibutyltin)	62	119
Mono-n-butyltin (as monobutyltin)	41	116

**Table B-10**  
**Laboratory QC Limits for Sediment Butyltins**  
**Blank Spike Recoveries**

Parameter	Lower Limit (%)	Upper Limit (%)
Tetra-n-butyltin (as tetrabutyltin)	46	115
Tri-n-butyltin (as tributyltin)	52	128
Di-n-butyltin (as dibutyltin)	10	115
Mono-n-butyltin (as monobutyltin)	10	200

**Table B-11**  
**Laboratory QC Limits for Sediment Butyltins**  
**SRM and Surrogate Recoveries**

Parameter	Lower Limit (%)	Upper Limit (%)
Tri-n-butyltin (as tributyltin)	10	137
Di-n-butyltin (as dibutyltin)	18	183
Mono-n-butyltin (as monobutyltin)	17	165
Tripropyltin (surrogate)	42	122
Triphenyltin (surrogate)	73	136



## **APPENDIX C**

### **Laboratory Information Management System (LIMS) Products and List Types**

**Table C-1**

**Table C-1**  
**King County Environmental Laboratory**  
**Laboratory Information Management System (LIMS)**  
**Products and List Types**

Parameter	LIMS Product	LIMS List Type
Ammonia	NH3	CVNH3-KCL
PSD	PSD	CVPSD
TOC	TOC	CVTOC
Total Solids	TOTS	CVTOTS
Total Sulfide	TOTSULFIDE	CVTOTSULFIDE
Mercury by CVAA	HG-CVAA	MTHG-MIDS, 6-MIDS
Other Metals by ICP	AL-ICP, SB-ICP, AS-ICP, CD-ICP, CR-ICP, CU-ICP, FE-ICP, PB-ICP, NI-ICP, AG-ICP, SN-ICP, ZN-ICP	MTICP-SED, 6-SED
BNAs (low-level)	BNASMS	ORSMS
Butyltins	TRIBUTYLTIN	ORBUTYLTIN
Chlorinated Pesticides (low-level)	PESTLL	ORPESTLL
PBDEs	PBDE	ORPBDE
PCBs (low-level)	PCBLL	ORPCBLL

CVAA – Cold vapor atomic absorption spectroscopy.

ICP – Inductively coupled plasma optic emission spectroscopy.